Evaluation of Infrared Sky Imagers for the Atmospheric Radiation Measurement Program

Victor R. Morris, Pacific Northwest National Laboratory
Dimitri Klebe, Denver Museum of Nature & Science
Ronald D. Blatherwick, University of Denver

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

Introduction

Nighttime cloud fraction has been and remains a critical programmatic gap in the US DOE Atmospheric Radiation Measurement (ARM) Program's observational dataset. Infrared sky imaging technology holds great promise in closing this gap and has the advantage that its ability to characterize clouds is identical for both day or night conditions. Therefore, instrument demonstrations were conducted at the ARM Climate Research Facility Southern Great Plains site in 2005, 2007, and 2009 to evaluate measurements of cloud fraction from different types of commercially-available infrared sky imagers.

Background

- Infrared sky imager system installed in October 2005
  - Blue Sky Imaging All Sky Thermal Infrared Camera
  - daytime measurements significantly underestimate those from Total Sky Imager (TSI)
- Infrared Sky Imager (IRSI) Intercomparison Study conducted in September 2007
  - compared measurements from five different types of infrared sky imagers
  - results did not provide a clear solution for obtaining nighttime cloud fraction
- Upgraded All Sky Infrared Visible Analyzer demonstrated in Summer 2009
  - Solmirus Corporation made significant improvements to hardware and retrieval algorithms
  - daytime images and cloud fraction data correlate very well with TSI

Instrument Specifications

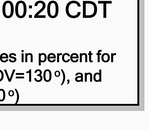
	Detector	Wavelength range (μm)	Field of view (°)	Min. time resolution (sec)	Min. temp. detected (°C)	Image resolution (pixel)
ASTIC	Ferro-electric	8 - 14	180	30	- 30	320 x 240
ASIVA	Micro-bolometer	8 - 14	130	0.5	-150	324 x 256
Nubiscope	Pyro-electric	8 - 14	140	600	-100	-
CIR-4	?	9 - 14	31	3	- 60	-

Objectives

- Produce nighttime cloud fraction product
- Capture hemispheric infrared images of the sky during both the day and night
- Compare cloud fraction and cloud height data with measurements from an existing IRSI, TSI, Ceilometer , and Micropulse Lidar
- Select instrument for deployment at sites

Instruments Tested

- Blue Sky Imaging All Sky Thermal Infrared Camera (ASTIC)
  - provides hemispheric sky images and cloud fraction at four fields-of-view
- Solmirus All Sky Infrared Visible Analyzer (ASIVA)
  - provides radiometric sky images, cloud percent, cloud/sky temperature, sky opacity, and water vapor determination
- Heitronics Nubiscope
  - provides cloud percent, cloud/sky temperature, cloud height, sky condition, and hemispheric cloud cover representation
- Atmos Cloud Infrared Radiometer (CIR-4)
  - provides cloud percent, cloud/sky temperature, and cloud height

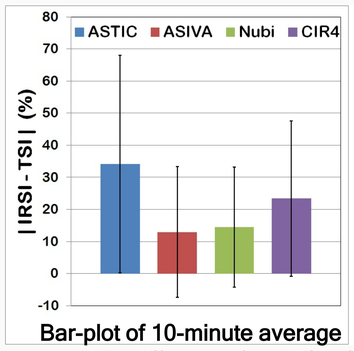


Sky Image Comparison

Summary

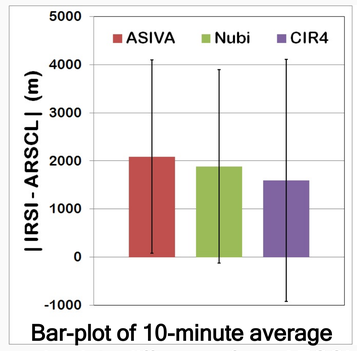
- ASIVA daytime sky images and cloud fraction values correlate very well with TSI and demonstrates considerable promise in providing nighttime cloud fraction data and additional products including cloud height, temperature, optical depth, and water vapor
- ASTIC sky images compare well with TSI but underestimates cloud fraction measurements
- Nubiscope cloud fraction measurements correlate well with TSI values but has poor time resolution
- Cloud height algorithms for each instrument, compared with Active Remotely-Sensed Cloud Locations (ARSCL), needs improvement

Cloud Fraction



Bar-plot of 10-minute average absolute difference from TSI of cloud fraction in percent

Cloud Height



Bar-plot of 10-minute average absolute difference from ARSCL of cloud height in meters

Acknowledgements

Jim Mather of PNNL for engineering and operations support.

David Breedlove of Native Energy & Technology for site operations and maintenance.

Hans Möller of Heitronics GmbH, Laurent Berger of Atmos Co., Montse Costa Surós of University of Girona, and Naomi Pequette of University of Denver for data analysis.

References

Morris, V.R. 2008. "The Infrared Sky Imager Intercomparison Study." In *Proceedings of the Eighteenth ARM Science Team Meeting*, U.S. Department of Energy, Washington, D.C.

Genkova, I., C. Long, T. Besnard, and D. Gillotay. 2004. "Assessing Cloud Spatial and Vertical Distribution with Infrared Cloud Analyzer." In *Proceedings of the Fourteenth ARM Science Team Meeting*, U.S. Department of Energy, Washington, D.C.

U.S. DEPARTMENT OF ENERGY | ARM CLIMATE RESEARCH FACILITY | DENVER MUSEUM OF NATURE & SCIENCE

AMS Annual Meeting
Symposium on Meteorological Observation and Instrumentation
23 January 2012

victor.morris@pnl.gov, 509-372-6144
www.pnl.gov